ISSN 0327-9375

THE TRUE DESERT OF THE CENTRAL-WEST ARGENTINA
BIOCLIMATOLOGY, GEOMORPHOLOGY AND VEGETATION

EL DESIERTO VERDADERO DEL CENTRO-OESTE DE ARGENTINA

BIOCLIMATOLOGÍA, GEOMORFOLOGÍA Y VEGETACIÓN

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ABSTRACT

In the NW sector of Argentina between the latitudes of Mendoza (32°53'S) and Jachal (San Juan) (30°15' S) extends a N-S oriented tectonic valley located between the Pre-Cordillera and the Front Cordillera of the Andes. This valley is 2,000-5,000 m deep with respect to the Pre-Cordillera and Cordillera summits that borders it on the East and West; it is ca. 300 km long and 40 km wide on the average. This is actually a perfect case of rain shadow desert comparable to the well known Californian Death Valley, with an hyper-arid climate. At the lowest point (Calingasta -San Juan-, 1,375 m) the long-term mean annual rainfall is only 54 mm and up to 100-120 mm on the highest points (Tambillos -Mendoza-, 2,164 m). From the geomorphic, climatic, floristic and vegetational viewpoints this post-tectonic graben is a true desert void of perennial vegetation on the pediments, while perennial species are contracted along the hydraulic network and around the topographic depressions. Vegetation on the pediments is set up in a steppe-like diffuse pattern in the highest parts above 1,800 m of elevation, and on a contracted pattern in the lower (1,300-1,800 m asl).

Keywords: Arid Land, Cordillera of the Andes, deserts, vegetation, geomorphology, shadow desert.

RESUMEN

En el sector NW de Argentina entre las latitudes de Mendoza (32º53'S) y Jachal (San Juan) (30º15'S), se extiende un valle tectónico, con orientación N-S, localizado

entre la Precordillera y la Cordillera Frontal de los Andes. Este valle se profundiza entre 2.000 y 4.000 m con respecto a las cumbres de la Precordillera y Cordillera Frontal, que lo bordean por el este y oeste respectivamente; además posee una longitud de aproximadamente 300 km y un ancho medio de 40 km. Realmente es un típico caso de desierto de sombra, comparable al bien conocido Valle de la Muerte en California, con clima hiperárido. En el punto más bajo (Calingasta -San Juan-, 1.375 m) la precipitación media anual es de 54 mm que alcanza los 100-120 mm en las mayores alturas (Tambillos -Mendoza-, 2.164 m).

Desde el punto de vista geomorfológico, climático, florístico y de la vegetación, este graben post-tectónico constituye un verdadero desierto libre de vegetación perenne en los pedimentos, mientras que las especies perennes están contraídas siguiendo la red de drenaje y alrededor de las depresiones. La vegetación de los piedemontes se presenta como un modelo difuso de estepa en la mayor parte por encima de los 1.800 m, y como modelo contraído en alturas menores, entre 1.800 y 1.300 m.

Palabras clave: *Zonas áridas, Cordillera de los Andes, desierto, vegetación, geomorfología, desierto de sombra.*

INTRODUCTION

The southern part of the Uspallata-Barreal valley is situated a few km N of Uspallata city (Mendoza) in an area called Pampa de Yalguarraz which drains to the north into the Río San Juan basin and to the south into the Río Mendoza catchment (32°36'S- 69°20'W, Alt. 1,880m. The northernmost part, Angualasto (San Juan), is on the Rio Jachal (30°03' S - 69°19' W, Alt. 1,704 m. The N-S distance is thus 300 km for an average width of 40 km, i.e. an area of 12,000 km^2. The northernmost part is practically on the confluence of the Pre-Cordillera and the Front Cordillera. This tectonic valley is filled with fluvio-glacial sediments of Mio-Plio-Pleistocene age. These may reach a thickness of 300-400 m in the central part of the Calingasta and Río Jachal valleys, and the graben's subsidence is of 1,000-1,200 m (Rodriguez *et al.*, 1998). The pediments are made of fluvio-glacial coalescent fans of post-tectonic quaternary age similar to those described in the Mendoza pediments by Polanski (1962, 1972). In the region of Iglesia, in the Río Jachal basin, there are large deposits of diatomites of several tens of meters thickness (Las Flores, Pismanta, Tudcum, Angualasto, Rodeo, and Iglesia cities). These non-tectonized deposits, are very dissected in bad-lands and bare of perennial vegetation. They date back to a Pliocene age (Wetten, 1975; Ragona *et al.*, 1995). They are topped by shingle and boulders from the upper pediment. These diatomites seem to be the remnants of a large Pliocene lake developed in the lower reaches of Rio Jachal, east of the Pre-Cordillera before the latter managed to find its way to the east through the Pre-Cordillera. These diatomites, albeit bare of any perennial vegetation cover, exude small springs of highly saline waters and therefore play a determinant role in the distribution of the neighbouring vegetation almost entirely made of halophytes and phreatophytes. The outcrops of the Pre-Cordillera rocks, contrary to the Front Cordillera, are almost totally of a sedimentary nature (with, however, some lightly metamorphized elements of various shales and schists) and they may be of various ages, Paleozoic (Cambrian, Ordovician, Gothlandian, Permian), Mesozoic (Triasic, Liasic and Cretaceaous) and Cenozoic (Miocene and Pliocene) in both continental and marine series. The petrographic sequences in these sediments include saline deposits: diapirs of evaporites, salt bearing marls, gypsum, anhydrite, etc. Present and past runoff on these saline sediments result downhill and downstream, gypsum crusts in the lower pediments, takyrs and salt mashes in the closed depressions.

The valleys of Calingasta on Río San Juan and of Iglesia on Río Jachal, between Villanueva and Tocota (35 km), are separated by an upland from the upper pediment located at 2,500-2,800 m: the Llanos del Leoncito. These constitute the higher and older pediment between the Cordillera Frontal (Cerro del Diablo) and the Pre-Cordillera (Sierra del Tigre). This plateau is the local water divide between the Rio San Juan and Rio Jachal basins. This high inter-cordilleras fluvio-glacial pediment is mainly made of boulders and shingle with a high petrographic diversity of extrusive rocks. Towards 10-20 cm of depth the soil develops a calcareous crust (caliche), of medium hardness, 5-20 cm thick. Contrary to the arid and hyper arid zones to the east of the Pre-Cordillera, the tectonic valley neither shows any sand-dunes nor any clay-dune systems (lunettes). The remote sensing signature images of the pediments in the eremitic zone ($P < 50$ mm) shows soft erosion look like dunes perhaps due to the contraction of perennial vegetation along the hydreous network and very soft topography.

Material and Method

Scarce climatological information on precipitation (P), mean temperature (T), potential evapotranspiration (ETP), was compiled from diverse sources (FAO, 1985; IIH, 1988a,b; De Fina *et al.*, 1992; INTA, 1999). The Potential evapotranspiration, and also rainfall, temperature, the percentage of semestrial summer and winter rainfall and hydrical deficit (ETP-P) for each locality were calculated. The area was bioclimatically classified. Soils were classified according to the 8ª approximation (Soil Survey, 2006).

Several floristic surveys were made considering both local and regional geomorphology: pediments, runnels, depressed areas. In each site the presence (Braun Blanquet´s method, 1979) and cover (Daget et Poissonet´s linear method, 1971) of all plants were recorded. At least ten releves and transects for each environment were performed. All plants colleceted were incorporated to Geobotany and Phytogeography Herbarium (IADIZA).

Results

Climatology and bioclimatology

From the climatic viewpoint, the tectonic valley may be classified as hyper-arid ($120 > P > 60$ mm) or eremitic ($60 > P > 30$ mm), depending on the sub-zone (Minetti *et al.*, 1986; Le Houérou, 1999).

The Figure 1 shows that the valley constitutes a typical case of a "Rain Shadow Desert", like the Death Valley of California, the best well known such case, in the USA.

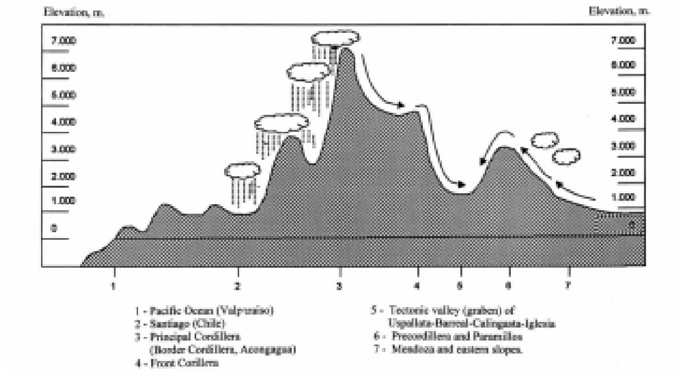

Figure 1. Scheme of the development of the Zonda wind
Figura 1. Esquema del desarrollo del viento Zonda

Considering the map of Minetti *et al.* (1986) based on the data of the period 1921-1950, the distinct rainfall belts may be differentiated as follows, covering the areas mentioned in the valley and its surroundings (Figure 2) (Le Houérou, 1999):

Rainfall zones	**Area (km^2)**
30-60 mm	2,500
	(Barreal-Calingasta Valley: 1,100 km^2 Iglesia- Rodeo Valley: 1,400 km^2)
60-120 mm	4,000
120-150 mm	5,500
Total	12,000

Figura 2. Schematic distribution of mean annual isohyets (data from 1921-1950 period) (adapted from Minetti *et al.*, 1986)
Figure 2. Distribución esquemática de las isohietas medias anuales (datos del período 1921-1950) (adaptado de Minetti et al., 1986)

Precipitation

The mean annual precipitation of the various stations are shown in Table 1. Naturally, the annual total depends on the reference period, as mentioned by Gonzalez Loyarte (1995). The mean of the reference period may vary by up to 50 %, as one can see in Table 2 (Barreal 42 mm to 122 mm, depending on the reference period, Le Houérou, 1999). This point deserves the main following comments:

A - Some stations in Table 1 have series of measurement of less than 20 years (n < 20), however the values are coherent with those from series of longer duration (n > 30) from the neighbouring reference stations: Rodeo, Barreal, San Juan, Jachal (Minetti *et al*, 1986) .

B – Moreover, we have surveyed in the field the relationship of these data with the distribution of natural vegetation and we found an excellent relationship (Le Houérou 1995 a, b, 1999).

C – Throught he evaluation of the mean decadal variation in time and space we can see that the mean decadal rainfall increased from the years 1950 until now, as mentioned by Gonzalez-Loyarte (1995).

Table 1. Mean annual precipitation in the desert zones under study (data from different sources, Le Houérou, 1999)
Tabla 1. Precipitación media anual en las zonas áridas en estudio (datos de diversas fuentes, Le Houérou, 1999)

Nº	Weather station	Lat.	Long.	Altit. (m)	Rainfall (mm)	VC x100	Period
1	Angualasto	30º03	69º19	1.704	43	53	1944-85
2	Tamberías	31º30	69º24	1.470	37	103	1945-84
3	Iglesia	30º24	69º12	1.800	34	100	1943-55
4	Rodeo	30º12	69º97	1.700	40	55	1969-83
5	Calingasta	31º23	69º24	1.375	54	85	1944-85
6	Sorocayense	31º33	69º26	1.530	55	47	1950-79
7	Barreal	31º39	69º29	1.650	61	61	1943-83
8	Mina Castaño	30º58	69º39	1.620	67	51	1939-61
9	Tucunuco	30º36	68º38	930	65	69	1923-80
10	Talacasto	31º06	68º38	954	83	60	1938-81
11	Niquivil	30º25	68º41	1.014	78	46	1938-81
12	San Juan (Observ.)	31º37	68º32	630	86	55	1880-1985
13	Jachal	30º15	68º44	1.162	115	42	1936-82
14	Tudcum	30º11	69º15	1.800	62	63	1950-83
15	Ullúm	31º26	68º39	808	77	70	1938-84
16	Santa Lucia	31º32	68º30	625	78	59	1926-64
17	Catinzaco	29º40	67º23	761	91	48	1921-59
18	Retamo	32º26	67º13	416	155	67	1971-85
19	Jocolí (Mza.)	32º31	68º41	590	95	55	1911-82
20	El Sauce	30º20	68º13		81	36	1974-85
21	Huaco	30º09	68º29	930	135	46	1921-50
22	Encón	32º12	67º54	453	165	56	1971-85
23	Uspallata*	32º28	69º18	1.782	106	40	
24	San Alberto*	32º27	69º23	2.171	112	40	
25	Tambillos*	32º20	69º27	2.164	120	40	
26	Mendoza (city)	32º53	68º52	827	206	38	

* from Roig & Martínez Carretero, 1998

Table 2. Fluctuation of mean decadal rainfall in Mendoza, San Juan, Jachal and Barreal (from Le Houérou, 1999)
Table 2. Fluctuación de la lluvia media decadal en Mendoza, San Juan, Jachal y Barreal (de Le Houérou, 1999)

Mendoza		Pocito (San Juan)		Jachal (San Juan)		Barreal (San Juan)	
Period	Mean	Period	Mean	Period	Mean	Period	Mean
1905/14	209.9	1904/13	83.9	1941/50	112	1943/52	64
1915/24	203.9	1914/23	87.7	1951/60	128	1953/62	49
1925/34	197	1924/33	98.7	1961/70	116	1963/72	42
1935/44	180.1	1934/43	78.4	1971/80	142	1973/82	66
1945/54	177.1	1944/53	86.3	1981/90	156	1983/92	122
1955/64	239.8	1954/63	105.1			1993/98	68
1965/74	198	1964/73	49.9				
1675/84	270	1974/83	100				
1985/94	271	1986/95	112				
n	9		9		5		6
Mean	216.31		89.1		130.8		68.5
St. Dev.	35.67		18.3		18.31		28.18
V.C (%)	16		21		14		41

Meteorological normals (Serv. Met. Nac. & CLINO)		Fifty years normals (1901-1950)
Mendoza (Park)	1931-1960= 198 mm 1961-1990= 232 mm	1901-1950= 191 mm
San Juan (Pocito)	1931-1960= 90 mm 1961-1990= 91 mm	1901-1950= 93 mm

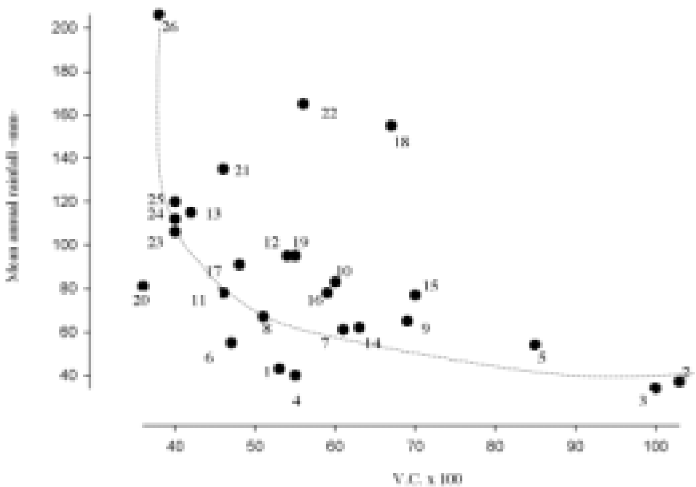

Figure 3. Relationship between mean annual rainfall and its coefficient of variation (data from Le Houérou, 1999)
Figura 3. Relación entre la lluvia media anual y su coeficiente de variación (datos de Le Houérou, 1999)

Interannual variability of precipitation.

The Figures 3 shows that the variability of annual rains in the arid and semi-arid zones of NW Argentina is inversely proportional with the mean, as in most arid zones of the world (Le Houérou, 1999). It can also be seen that variability increases much faster when the mean falls below 200 mm. This, again, is coherent with the other arid zones of the world. In the valley under study the coefficient of variation rises to 80-100 % in the most arid parts (Rodeo, Calingasta, Barreal, etc.). These values are similar to those from other hyper-arid and eremitic zones of the world (Le Houérou, 1989, 1990; Le Houérou *et al.*, 1993).

The Variability Index (V.I.) is the quotient between the difference of decile 9 and decile 1 to decile 5 (the Median): V.I. = D9-D1 / D 5. This Index has the advantage of not being related to the type of statistical distribution of the variable (Gaussian or assymetric), contrary to the coefficient of variation which should only apply to Gaussian distributions. The V.I. shows values comparable to the V.C. In 50 arid and semi arid stations of NW Argentina the correlation between both is r = 0.90. The values of V.I. for the arid zones of the central western Argentina range from 1.0 to 2.5, as in the other hyper arid and eremitic zones of the world (Le Houérou *et al.*, 1993; Le Houérou, 1999).

The annual ETP reaches 1,002 mm in Barreal and 1,078 in Rodeo, as computed via the ETP = 68.64 t approximate equation (Le Houérou, 1989), being t= 14.6º and 15.7º for Barreal and Rodeo, respectively. The water deficit (ETP-p) in this case is 1080 – 61 = 1019 mm and 1078 – 40 = 1038 mm, respectively (rainfall according Table 1). (P = Mean annual precipitation –mm- ; t = mean annual temperature -°C-, ETP = mean annual evapotranspiration -mm).

In the tectonic valley the seasonal distribution is of an attenuated tropical type, with the exception of Barreal, which shows a secondary, but significant, peak of winter precipitation. The percentage of semestrial summer rains (SP: Oct.-March) in the annual total (TP) is as follows for the various stations of the valley and surroundings (according to Le Houérou, 1999):

Stations	SP / TP %
Barreal	68
Villavicencio	73
Uspallata	75
San Juan	81
Jachal	82
Rodeo	87

In the Precordillera the regime is of a tropical type to the north and attenuate tropical type to the south toward the villages of Villavicencio, Uspallata, Las Aguaditas (Le Houérou, 1999). In the Cordillera, to the contrary, the precipitation regime is totally distinct or even opposite with over 75 % winter semester (WP: April-September) precipitation (Minetti *et al.*,1986 ; Le Houérou, 1999). In fact the precipitation regime in the Cordillera, between latitudes 30º and 35° S, is as follows:

Station	WP / TP %
Cristo Redentor	78
Alto Río de Los Patos	81
Pachón	84
Puente del Inca	86

The Main Cordillera (C. Principal) and the Front Cordillera (C. Frontal) exhibit a Mediterranean type of rainfall distribution, with over 75 % of winter precipitation, similar to the one prevailing on the Chilean side of the Cordillera (Minetti *et al*, 1986; Le Houérou, 1999).

Temperatures

The mean annual temperature depends on the elevation. Winters are cold in the valley, with daily mean winter temperatures of 7º and 8° C in July in Barreal and Rodeo, respectively. Days are sunny and mild but nights are cold to very cold. The annual frost-free period (t > 15°C) is 155 days in Barreal and 215 days in Rodeo.

Bioclimatic classification

The bioclimate of the valley could be classified as Eremitic of Tropical regime in Rodeo and Eremic of attenuated Tropical regime in Barreal, both with cold winters (Le Houérou, 1999; Martínez Carretero, 1995). The higher parts of the pediments above 2,000-2,500 m a.s.l.(Uspallata,Yalguarraz, Tambillos, Tocota, Alto del Colorado, etc.), with a mean annual rainfall (MAR) of 100-120 mm may be classified as Arid zones *s.s.* at the limit of Hyper-arid. These higher parts support a dwarf shrub steppe vegetation while the lower elevations, below 1,800 m, exhibit an hyper-arid contracted vegetation along the runnels, with bare pediments.

The "Zonda" wind

The "Zonda" wind is a Foehn-like similar to the Chinook of the Rockies or the Santa Ana of California. It blows, on the average, 16 days per annum (1-30) in Pocito (San Juan); it occurs in all seasons but 50 % of the events occur in the spring time (SON) and 30 % in the winter season (JJA). The mean maximun temperature in winter (July) is of 16.8ª and it may rise up to 34 °C under zonda condition, and the mean maximun temperature in spring (October) is of 26.4 °C that reaches 42.5ºC. Each event lasts an average 7 hours (1-24) and the atmospheric humidity may drop to 5 % on the average (0-22 %), with rare values of 0.0 %. Such conditions may raise the evapotranspirative demand of 2-4 mm. day^{-1} above season's normal. (Le Houérou, 1999). The valley is the area most affected by Zonda wind in the NW Argentina. The structure of the relief on both sides of the tectonic valley contributes to the formation of this rain shadow for both the rains coming from the Atlantic (Precordillera) and from the Pacific (Main Cordillera) (Figure 1).

Geology, Geomorphology, Soils

As we have seen above, the central part of the tectonic valley is essentially constituted by 3 levels of boxed Quaternary pediments made of coalescent fluvio-glacial shingle and pebble "fanglomerates" (Polanski, 1962, 1972). These formations of boulders and pebbles have a 20-40 % matrix of sand and silt; they are very similar to those described by Polanski (1962) in the Andean foothills of Mendoza and named by him: Meson, Invernada and Las Tunas from older to younger and higher to lower in elevation. Nonetheless, the pediments of the tectonic valley differ from those of Meson and Invernada by their topographic position and their detritic composition inasmuch as there are no big boulders here, whereas Meson and Invernada contain boulders of over 1 m^3 in size that are absent here. The "fanglomerates" of the tectonic valley, on the contrary, are very similar to the La Tunas formation of the Mendoza foothills as described by Polanski (1972), but with same differences in its colour and lacking of calcareous cementation. These differences may be attributed to the difference in climate: hyper arid in the tectonic valley and semi-arid to sub-humid in the Mendoza foothills. Polanski attributes an Upper Pleistocene age to Las Tunas formation (Würm / Wisconsin in the Europaean and N American terminologies, respectively). It thus looks probable that the fanglomeratic formation of Barreal-Calingasta-Rodeo be of the same age as Las Tunas. As in the Sahara the surficial temperature of the bare exposed pebbles on the surface of the pediments (desert pavements), at the contact with air and solar radiation, may reach a temperature up to 70°C in summer and –20°C in winter (given the absolute maximas and minimas registered under shelter). Similarly, the atmospheric humidity at ground level may vary from ca. 0.0% in Zonda weather up to the dew point during the cold nights. For these reasons the presence of a desert varnish (a coating of Iron and Manganese oxides film) characteristic of true deserts, is observed in the hyper-arid and eremitic parts of the valley, below an elevation of ca. 1,800 m and 100 mm of mean annual rainfall (MAR). This is coherent with the situation in other true deserts of the world (Sahara, Namib, Takla Makan (Africa), Lower Colorado (USA), northern Chile-southern Peru, etc.).

Deposits of diatomites are conspicuous in the valley of Iglesia (Rodeo, Pismanta, Las Flores, Tudcum, Anguallasto) (Suvires, 1998; Caminos y González, 1996), they are given an age of Upper Pliocene to Holocene (Wetten, 1975). They may reach up to 100 m in thickness, usually topped by Early and perhaps Middle Pleistocene pebble pediments, when least eroded. The outcrops of this formation cover an area of 500 km^2, approximately in the valleys of Iglesia, Rodeo, Colanguil, and Río Blanco, and also at the western foothill of the Pre-Cordillera between the valleys of Río Jachal and Alto del Colorado. These diatomites, very saline, are eroded in band-land gullies, and bare of perennial vegetation.

There are no developed soils on the pediments of the eremitic zone (P < 50 mm) due to the lack of organic matter and water. The rare plant individuals grow on a shallow edaphic fanglomeratic substrate of shingle with some 20 % of fine sand and silt and 80 % pebbles. The low parts of the topography in the same area are made of Entisols (Xerorthents and Torriorthents) ands Aridisols (Calciorthids, Gypsiorthids, Salorthids). In the hyper-arid zone (120< P < 60 mm) the pediment soils are Entisols (Xerorthents), Inceptisols (Xerochrepts), Aridisols (Camborthids, Calciorthids with Caliche, Gypsiorthids) and Salorthids (Solontchaks) in the valleys and topographic depressions.

Vegetation

The vegetation of the Uspallata-Iglesia tectonic valley may be classified in three large units. : steppe (scattered), contracted (clustered) and phreatophytic (bolsones).

Steppe. The steppe vegetation is made out of dwarf shrubs regularly albeit, sparsely distributed over the interfluves, with a vegetation ground cover of 5 to 10%, occasionally 50 % (mean cover 10%), and a height of less than 100 cm. This type of vegetation is found on the higher pediments in the upper parts of the valley between the elevations of 1,800 and 2,800 m under a MAR of 80-120 mm/ year rainfall. Typical areas are the surroundings of Uspallata and Yalguaraz localities (Martínez Carretero, 2001; Roig & Martínez Carretero, 1998), at the border of the Mendoza and San Juan provinces and around Tocota and the Llanos del Leoncito on the north-western side of the valley in the Rio Jachal catchement. It shows up as a kind of low, open thicket dominated by creosote bushes (*Larrea divaricata*, *L. cuneifolia* and *L. nitida.*) which constitute the upper stratum 30-80 cm high. There is, in addition, a lower stratum of 10-30 cm made of therophytes and short perennial grasses. The aerial biomass present is estimated in the vicinity of 1,000-2,000 kg DM ha^{-1}, depending on site; some 80 % of the biomass comes from the shrubs. The dwarf shrub stratum is composed of *Acantholippia seriphioides, Artemisia mendozana, Atriplex lampa, Chuquiraga erinacea, Fabiana peckii, Larrea cuneifolia, L. divaricata, L. nitida, Lycium chilense, Prosopis flexuosa* var. *depressa, Schinus fasciculata,* among others (Table 3). The lower stratum (10-30 cm) exhibits a variable ground cover, depending on range management and on the seasonal rains as far as the therophytes are concerned. Among the short perennial grasses on we may cite: *Aristida mendocina, Chloris castilloniana, Digitaria californica, Elymus erianthus, Munroa mendocina,* etc.

Table 3. Floristical composition and specific cover
Table 3. Composición florística y cobertura específica

		Contracted	
	Steppe	**1º orden**	**3º orden**
Mean plant cover (%)	10	12	20
Hight plant (cm)	60	60-75	100-140
Biomass (kg DM.ha-1)	1,000/2,000	500/1,000	2,000/5,000
Acantholippia seriphioides	10	•	•
Artemizia echegarayii	5	•	•
Artemizia mendozana	20	•	•
Baccharis retamoides	5	•	•
Bredemeyera microphylla	5	•	•
Chuquiraga erinacea	5	•	•
Prosopidastrum globosum	5	•	•
Senna aphylla	5	•	•
Trycicla spinosa	5	•	•
Zuccagnia punctata	10	•	•
Chloris castilloniana	5	•	•
Digitaria californica	5	•	•
Elymus eryanthus	5	•	•
Munroa mendocina	15	•	•

Schismus barbatus	5	•	•
Scleropogon brevifolius	25	•	•
Setaria leucopila	5	•	•
Stipa ichu		10	• •
Stipa plumosa	5	•	•
Stipa vaginata	5	•	•
Atriplex lampa	•	15	20
Prosopis flexuosa var. *depressa*	•	15	25
Proustia cuneifolia	•	20	40
Acacia furcatispina	•	20	40
Atriplex lithophila	•	5	10
Cercidium praecox ssp *glaucum*	•	15	15
Grabowskya obtusa	•	10	25
Prosopis alpataco	•	2	2
Fabiana peckii	•	10	•
Larrea cuneifolia	•	10	•
Larrea divaricata	•	15	•
Larrea nitida	•	25	•
Atriplex spegazzinii	•	5	•
Baccharis darwinii	•	15	•
Bredemeyera colletioides	•	5	•
Bulnesia retama	•	20	•
Heliothropium curassavicum	•	5	•
Heliothropium mendocinum	•	2	•
Solanum elaeagnifolium	•	5	•
Lycium chilense	5	•	5
Schinus fasciculata	5	•	10
Junellia aspera	20	•	10
Aristida mendocina	10	•	10
Pappophorum philippianum	10	•	10
Acacia caven	•	•	25
Atriplex crenatifolia	•	•	10
Baccharis salicifolia	•	•	35
Prosopis calingastana	•	•	15
Prosopis sericantha	•	•	5
Prosopis strombulifera	•	•	20
Tamarix af. *gallica*	•	•	10
Tessaria absinthioides	•	•	30
Aristida adscensionis	•	•	5
Distichlis scoparia	•	•	25

Contracted vegetation. This kind of distribution pattern corresponds, as in all true deserts of the world, with the hyper-arid and eremitic zones (MAR < 100 mm/ year^{-1}). Pediments and interfluves remain permanently bare of perennial plants which concentrate in the thalwegs and runnels. One thus may distinguish runnels of first, second, third, etc. order. In these, some additional runoff allows for the survival of perennials (Martínez Carretero, 1993).

Runnels of first and second order

The vegetation of gullies and runnels may be classified as a function of the frequency of actual runoff, hence of the edaphic water availability on the long term. We may thus talk of first, second or third order runnels. The vegetation structure accordingly becomes increasingly complex and the biomass higher as the water present in the soil on the long term increases, that is to say with the rank order of the runnel.

The runnels of first order exhibit a sparse dwarf shrubs vegetation with rare perennial grasses, similar to the diffuse steppe vegetation in the less arid zones but with a lighter perennial plant cover and biomass than the latter. Maximum height is 50-200 cm, perennial canopy cover 5-20% (mean cover 12%) and perennial biomass 500-1,000 kg DM ha^{-1}. Among the dominant species one may mention: *Acacia furcatispina, Atriplex lampa, A. lithophila, A. spegazzinii, Bulnesia retama, Cercidium praecox* ssp *glaucum, Grabowskia obtusa, Proustia cuneifolia, Solanum elaeagnifolium*, etc.

In many cases first order runnels exhibit monospecific or quasi-monospecific populations of *Bulnesia retama* as for instance in the vicinities of Barreal and Calingasta.

Runnels of third order and playas (= "bolsones")

These parts of the hydrous network support a more abundant and diverse vegetation, based on halophytes and phreatophytes. The height of the upper stratum reaches 2-3 m and the perennial canopy cover is 20-45%, up to 80 % (mean cover 20%), while the biomass is of the order of 2,000-5,000 kg DM ha^{-1}. The dominant species in these runnels and ribulets are: *Acacia caven, A. furcatispina, Atriplex crenatiolia, A. lampa, A. lithophila, Baccharis salicifolia, Grabowskia obtusa, Prosopis strombulifera, Proustia cuneifolia, Senna aphylla, Tamarix* af. *gallica, Tessaria absinthioides,* etc.

Conclusions

The intra-Andean tectonic valley of Uspallata-Calingasta-Iglesia-Rodeo located between the Pre-Cordillera and the Main-Cordillera is a relatively small area of 12,000 km^2, but its ecological conditions are unique at the east of the Andes. It can be classified as hyper-arid (120 > P > 60 mm) or eremitic (60 > P > 30 mm). Bioclimaticaly this valley could be considered as Eremitic of Tropical regime in Rodeo, at the northern, and as Eremic of attenuated Tropical regime in Barreal, at the southern.These are in many respects similar to many true deserts of Africa (Makama), Asia (Takoa), Atacama, Chile-Peru, and of the High Andes. It offers the characteristics of a rain-shadow true desert, comparable to the Death Valley of California / Nevada (USA), to mention a well known such case. In relation to the latter desert area, both share halophyte and phreatophyte plants, functional types, saline soils dominance, and concentrated-dispersal model of vegetation, among others characteristics.

Geomorphologic characteristics are typical of true hot deserts with three boxed pediments made of coalescent fluvio-glacial "fanglomerates". The surface of pebbles exposed to the air and sun are coated with a desert varnish in the hyper-arid and eremitic areas.

Vegetation in the drier parts is "contracted", often dominated by the tall shrub *Bulnesia retama,* a perennial plants that are clustered along the drainage network, while pediments are bare of permanent vegetation. The vegetation of the upper pediments is made of a sparse dwarf shrub steppe dominated by creosote bushes (*Larrea* div. spp.). The vegetation of the tectonic valley clearly belongs to the Monte Phytogeographic Province.

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Recibido: 04/2006
Aceptado: 11/2006

Acknowledgements

The authors should like to hereby express their deep appreciation to all friends working in IADIZA, for their support, assistance and participation in discussions both in the field and lab.